CONGESTION RELIEF ANALYSIS

For the Central Puget Sound, Spokane & Vancouver Urban Areas

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Table of Contents

Abstract

In response to the issue of roadway congestion and travel delay in urban areas of Washington State, in 2003, the Washington State Legislature asked WSDOT to conduct a congestion relief analysis for the State's three major urban areas: Central Puget Sound, Spokane and Vancouver. The legislature directed that "*the study must include proposals to alleviate congestion consistent with population and land use expectations under the Growth Management Act, and must include measurement of all modes of transportation*."

The *Urban Areas Congestion Relief Analysis* examined a variety of congestion relief scenarios in the Central Puget Sound, Vancouver, and Spokane regions. Its purpose was to answer the questions, "What would it take to significantly reduce expected future traffic delay due to congestion in the State's major urban areas?" and "What are the associated costs and impacts?" The study was conducted based on adopted regional growth management plans as required by the Growth Management Act of 1990. In addition to those listed on the cover, Sound Transit, King County Metro, Clark County Transit and Spokane Transit also participated in the study.

This study documents the results of computer modeling of a variety of automobile, high-occupancy vehicle (HOV), transit, transportation pricing, and travel demand management scenarios singly and in combinations.[1] The analysis was performed with the assumption that people will continue to make travel decisions in 2025 as they do today, and there will be no significant transportation technology advances from now until then. The results of the computer analysis provide perspectives on how effective strategies limited to these scenarios could be in reducing travel delay[2] relative to the 2025 baseline conditions[3] in Washington State's three largest urban areas. Here are the major conclusions:

Caution should be taken in relying on these results because of the limitations of the travel demand forecast models[1] used in the analysis and uncertainties associated with forecasting travel behaviors far into the future in general.

- **As the urban areas grow, congestion will grow too**. The computer analysis showed that, without a substantial increase in transportation capacity or significant changes in travel behavior, by 2025, total travel delay could increase between 3 to 5 times in the three major urban areas.

- **Large-scale roadway expansion** could reduce travel delay on highways. However, future population and job growth would overwhelm the ability of the most extensive capacity expansion scenarios tested in this study to reduce total regional delay to below today's levels. Furthermore, due to man-made and/or natural environmental constraints, it is estimated that the cost to reduce travel delay in 2025 to below today's level could well exceed $100 billion dollars in the Central Puget Sound region alone.

[1] This analysis is not meant to recommend a specific strategy or to replace, update, or propose a specific local, regional or statewide plan, policy or agreement.
[2] In this analysis, a very basic indicator used to measure congestion is travel delay. Travelers are assumed to be experiencing delay when the traveling average speed is lower than the posted speed limits.
[3] The 2025 baseline conditions included the existing facilities plus projects that had secure funding prior to the 2005 legislative session. Since most analysis was done in 2004, the new transportation projects funded by the 2005 Transportation Partnership Account were not included in the 2025 baseline.

- **Major transit expansion** in the three urban areas would provide an alternative to single occupancy vehicles for people traveling congested corridors during peak periods. However, according to the computer modeling, transit expansion alone is not shown to be effective in reducing total delay at the system level. The lack of supportive land use densities and the difficulty in serving non-commute travel limits the ability of transit to serve trips that are now customarily made by auto.

- **Combining roadway and transit improvements** to match the unique characteristics of particular corridors is shown by the modeling to provide the potential for more practical congestion relief when compared to single strategies. The monetary cost for the combined improvement would not be cheaper than the roadway improvement alone in order to achieve the same level of travel delay reduction.

- **Region-wide value pricing** (roadway toll rates vary according to demand levels) is indicated to be very effective in reducing total delay. Roadway tolling helps to dampen travel demand, shorten trips, shift travel to non-peak periods, and encourage use of other travel options (transit, carpooling, biking and walking) that are not subject to toll charges. Value pricing helps to maximize the efficiency of our transportation system. Value pricing is consistent with the way almost all other utility and transportation services are provided in market-based economies (for example, water, electricity, air travel and telecommunications services). As with the use of prices to establish access to services in other utility areas, special provisions may be necessary to assure adequate access by those unable to pay market prices for indispensable services. The special requirements need to be carefully considered.

- **Value pricing in the form of High Occupancy Toll (HOT) lanes** is found to reduce corridor delay and make the corridor operate more efficiently. HOT lanes make corridor travel time more reliable, which benefits everyone, including occasional users.

- **A strategic combination of transportation supply and demand management** is suggested by the computer models to be effective in fighting the growing demand and capacity imbalance. When value pricing is added to a mix of highway and transit capacity improvements, the model analysis showed a large increase in benefits for a small additional cost. This combination of capacity improvements and value pricing should be given much greater attention as an implementation strategy.

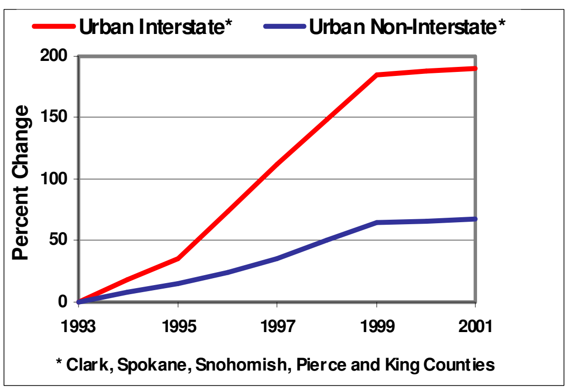
Executive Summary

Why is Congestion Growing in the State? – A Demand /Capacity Imbalance

Roadway congestion is one of the most pressing transportation issues facing some parts of Washington State today. During the past 20 years, traffic congestion has increased substantially in the State's urban areas, where two-thirds of Washingtonians live (Figure 1). Today, congestion in the form of delay exists for several hours each day in the large urban areas.

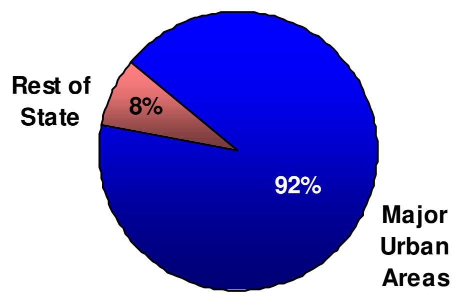
The delay to motorists caused by roadway congestion is most evident on many highways and even arterials in the State's three largest urban areas – Puget Sound, Vancouver, and Spokane. These three major urban areas experienced 92% of the total hours of congestion delay, as shown in Figure 2.

Figure 1: Growth in Daily Hours of Delay



Source: WSDOT

Figure 2: Total Hours of Delay in Washington State (2001)

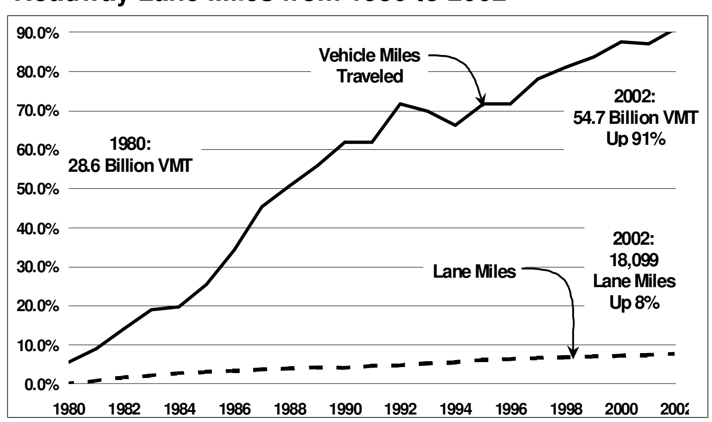


Source: WSDOT

How did we get in this situation? There are several reasons:

- More people are driving and people are driving more.
- Capacity expansion has not kept up with the pace of population and travel demand growth, resulting in an imbalance between demand and capacity.
- Most travelers are auto dependent due to lack of population and employment density, which is essential to make alternative travel options more viable.

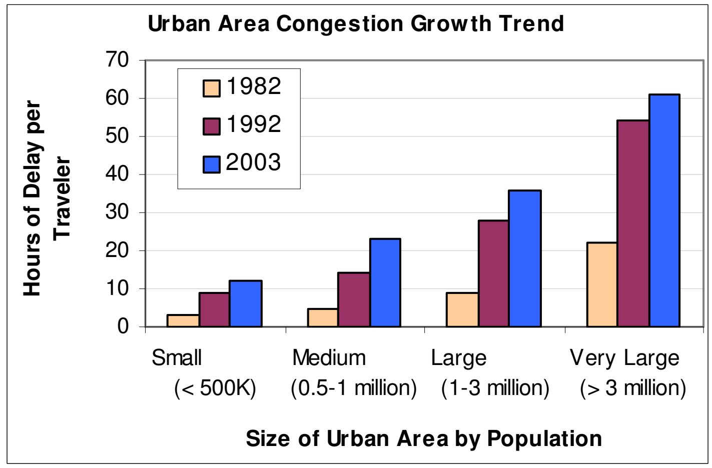
Figure 3: Growth in Statewide Vehicle Miles Traveled and Roadway Lane Miles from 1980 to 2002



Source: WSDOT, TDO

More people are driving and people are driving more. Between 1980 and 2003, Washington's population grew by 45%, the number of workers grew by 55%, and the number of vehicles increased by 77%. While highway travel has increased sharply, investment in expanded highway capacity has not matched the rapid growth in demand. As shown in Figure 3, the number of vehicle miles traveled (VMT) nearly doubled (+91%), while the number of lane miles increased by only 8%.
This growing demand-capacity imbalance in the State of Washington is a reflection of the national trend. According to the Texas Transportation Institute, "congestion has grown in urban areas of every size. Measures in all of the population size categories show more severe congestion that lasts a longer period of time and affects more of the transportation network in 2003 than in 1982[4]." This trend is shown in Figure 4.

Figure 4: National Trend: Growth in Travel Delay 1982 to 2003

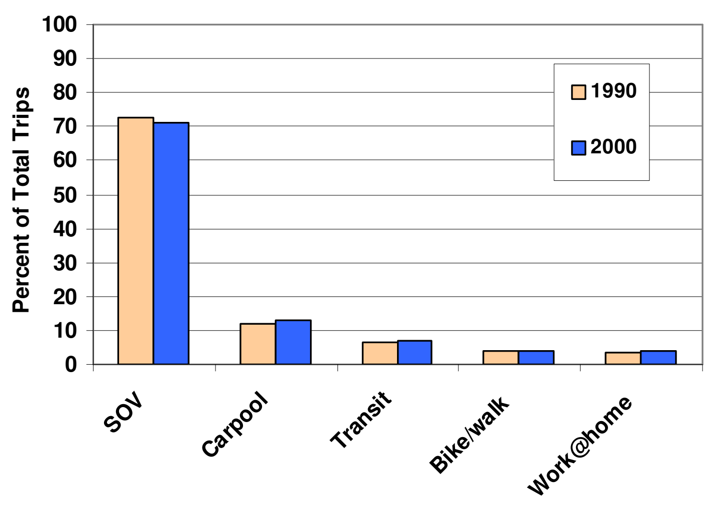


Source: the 2005 Urban Mobility Report, Texas Transportation Institute

Washingtonians, like people in the rest of the country, are heavily dependent on automobiles. In 1990, almost 74% of the State's 2.8 million workers drove alone to their jobs.

As a policy response to these and other issues presented by growth, the Washington State Legislature enacted the Growth Management Act (GMA)[5] in 1990. The GMA requires cities and counties to plan for how land will be used and population and jobs distributed within the Urban Growth Areas. The Act further specifies that the land use element be the foundation of the comprehensive plan. The process of designating future land uses must account for projected population growth and also provide for adequate levels of public facilities and services. Currently, 29 counties and 218

Figure 5: Work Trips by Mode in the Central Puget Sound Region



Source: 2000 Census

[4] The 2005 Urban Mobility Report, Texas Transportation Institute, 2005
[5] One of the primary focuses of the GMA is to locate development in defined urban growth areas and encourage development that has a mix of employment, housing and other activities. This will enable better use of transit and reduce travel distances.

cities representing 95% of the State's population are planning under the GMA.

In Central Puget Sound, the regional transportation strategies set in the Vision 2020[6] focus on establishing a more balanced transportation system, shifting emphasis from highways and single-occupant vehicle travel to different travel options backed by the envisioned higher density development. But the desire to find housing at costs to match their budgets has caused many people to live further away from employment centers. Consequently, land use densities in many urban areas and corridors have remained at low levels that make it difficult for other travel options (bike, walk and transit) to be viable alternatives to today's patterns of automobile use. As shown in Figure 5, the increasing use of alternative travel options during the 1990s has not been enough to offset the increase in vehicle travel during the same time period.

What Can We Expect In The Future?

According to the State's Office of Financial Management, by the year 2025 Washington's population will increase from approximately 5.9 million to 7.9 million residents, and a growing economy will increase employment from 2.74 to 3.64 million jobs. The three major urban areas will incur 69% of the population growth and 79% of the employment growth. Table 1 shows the forecasted growth in the Central Puget Sound, Vancouver, and Spokane regions for the period between 2000 and 2025.

Table 1: Forecasted Regional Growth 2000 to 2025

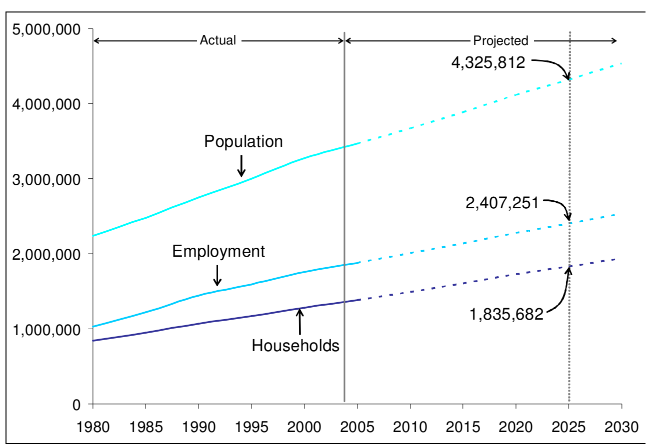
	Central Puget Sound		Vancouver		Spokane	
New Residents	+ 1,050,000	+32%	+ 146,000	+42%	+ 207,000	+47%
New Jobs	+ 660,000	+37%	+ 109,000	+69%	+ 98,000	+49%
New Vehicles	+ 928,000	+36%	+ 104,000	+42%	+ 146,000	+46%
New Work Trips[7]	+ 1,058,000	+47%	+ 209,000	+69%	+ 177,000	+51%

Source: State Sub County Forecasts, 2000 Census, and the regional forecasting models.

Central Puget Sound

In the 25 years from 2000 to 2025, the population in the four-county[8] Central Puget Sound region is expected to increase by 32%, with one million more people living in the region (Figure 6). During this same period, the region will attract almost 700,000 new jobs. The majority of the job growth is expected to occur in King County, while Snohomish and Pierce Counties will experience a faster pace of population growth.

Figure 6: Central Puget Sound Growth Forecasts



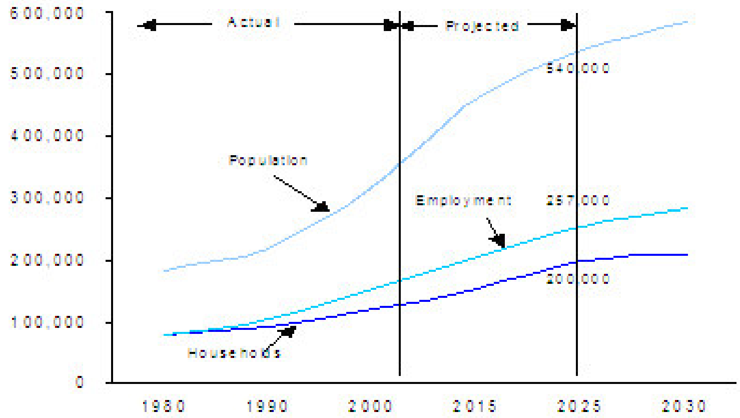
Source: PSRC, OFM and WSDOT Data Library

[6] VISION 2020 is the long-range growth management, economic and transportation strategy for the central Puget Sound region.
[7] Commute trips are one-way person-trips between home and work; total daily commute trips are approximately double the employment level.
[8] King, Pierce, Snohomish and Kitsap County are included in the Puget Sound study area.

Vancouver Area

In the Vancouver area, the population is expected to increase by 42% from 2000 to 2025 (Figure 7). Employment will grow faster, by almost 70%, as the Vancouver area seeks to become a larger employment center. Much of this growth is expected to occur in the designated urban growth areas of Battle Ground, Ridgefield, La Center, Camas and Washougal.

Figure 7: Vancouver Growth Forecasts

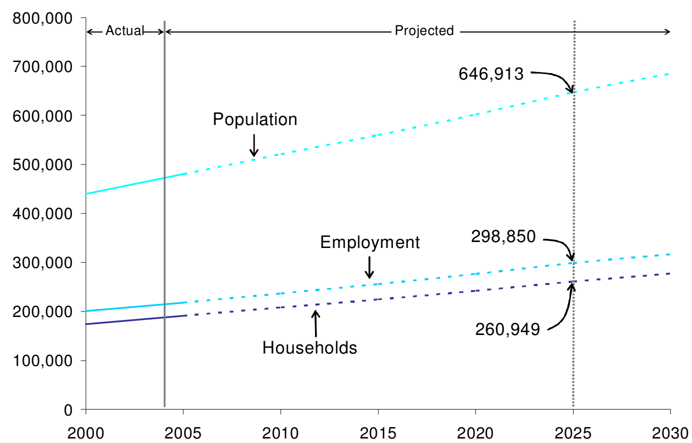


Source: RTC, OFM and WSDOT Data Library Vancouver Area

Spokane Area

For the Spokane area, population and employment are projected to grow by almost 50% between 2000 and 2025 (Figure 8). Population growth will be most pronounced in Spokane Valley, Liberty Lake, Deer Park, Geiger Heights and the Nine Mile Falls areas. Employment growth is mostly expected to occur within the central urban area, especially along the Division Street corridor and east of downtown along I-90 and SR 290.

Figure 8: Spokane Growth Forecasts

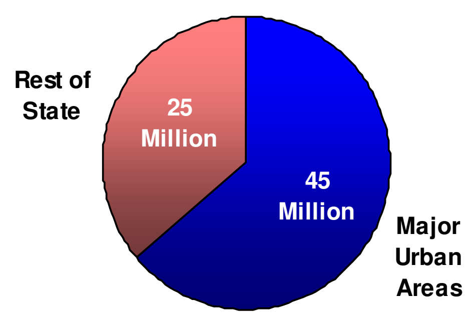


Source: SRTC, OFM and WSDOT Data Library

How Will Growth Affect Future Travel?

The projected population and employment growth will translate into substantial increases in travel demand. The computer models projected that a total of 45 million more vehicle miles of travel (VMT) per day will occur in the State's three major urban areas (Figure 9). Figure 10 shows the forecasted growth in VMT for each region. In Central Puget Sound, daily VMT is forecast to increase by nearly 60% by 2025; in Vancouver (Clark County), daily VMT is forecast to increase by 62% and in Spokane by 30%.

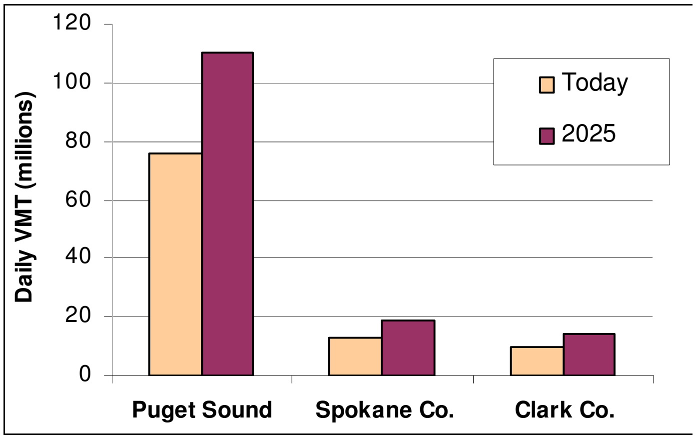
Figure 9: Projected Growth in Vehicle Miles Traveled in Washington State



Sources: SRTC, PSRC, RTC, OFM and WSDOT

According the computer models, travel patterns will also change within the regions, due in large part to the dynamics of population and employment growth and the availability of transportation capacity. In the Central Puget Sound region, although the number of trips will increase, the share of regional trips to, within, and from the City of Seattle will decrease from 22% today to around 18% in 2025. Conversely, trip making in other parts of the region will grow at a faster pace.

Figure 10: Comparison of Daily VMT in Major Urban Areas



Sources: SRTC, PSRC, RTC, OFM, WSDOT Data Library, and WSDOT Travel Delay Program.

In the Vancouver region, the expected population growth in outlying areas will funnel most of the travel growth to a handful of state highways. In addition, I-5 and I-205 are the only highways linking Vancouver and Portland. The demand for vehicle trips crossing the Columbia River bridges could increase by 50% over today's conditions.

In Spokane, growth in population in outlying areas, including Spokane Valley and Liberty Lake, will put higher travel demands on the I-90 corridor. Additionally, north-south arterials will see increased demand from growth in north Spokane County.

As travel demand grows, the imbalance between roadway demand and capacity will grow. The capacity built decades earlier in the major urban areas has been consumed. Without substantial new capacity, the projected population and job growth will put additional pressure on the already strained highway system in the State. The primary effects will be increased congestion, longer travel times, and reduced efficiency of the transportation system. These effects may lead to reduced productivity, higher costs for goods and services, and significant burdens of time lost to congestion in people's lives.

By 2025, without substantial new capacity or significant changes that affect how/ when we travel, users of Washington's transportation system will experience:

- *Increased delay*
- *Longer travel times*
- *Reduced efficiency*

Increased Congestion

Travel delay and congestion duration are expected to continue to increase. In the Central Puget Sound region, the average delay per vehicle trip during the afternoon peak period is expected to nearly triple, with delay time loss increasing from five minutes to 14 minutes per trip. Combined with more travelers, this would result in quadrupling total daily delay for vehicles on the roadway system in 2025 (from 285,000 to 1.12 million hours per day). Substantial increases in delay time losses are also expected in the other two major urban areas: a 400% increase in daily delay is expected for the Vancouver area, and a more than 100% increase for the Spokane region.

In the Central Puget Sound region today, most major freeway corridors experience extended periods of congestion. On average, vehicle flows are impeded approximately five hours per day.

The most congested facilities are I-5, I-405, SR 520 and SR 167. By 2025, without a substantial increase in transportation capacity or significant changes in travel behavior, traffic flows in all corridors are forecast to deteriorate, with computer models showing that freeway corridors would experience about nine hours of congestion a day. Much of the growth in congestion is predicted for the northern portion of the region along I-5 in North Seattle and Snohomish County, I-405 north of Bellevue, and SR 522 to Monroe. Conditions are also forecast to deteriorate along I-5 and SR 167 in South King/North Pierce Counties and along SR 18.

In the Vancouver region, most of the highway corridors within Clark County currently experience less than one hour of congestion per day, while the I-5 and I-205 crossings of the Columbia River experience about two hours of congestion in each direction[9]. In Oregon, highway corridors experience between one and two hours of congestion per day. The duration and severity of roadway congestion is projected to continue growing over the next 20 years. By 2025, the duration of congestion on the I-5 and I-205 Columbia River crossings and on I-84 in Portland as modeled by computers is expected to more than double, with four to five hours of congested conditions per day. The congestion duration in other major corridors is also predicted to double by 2025 to around three hours.

In the Spokane region, the major roadway corridors are currently experiencing less than two hours of congestion per day. The exceptions are Division Street, which currently has two to four hours of congestion, and I-90 east of downtown, which experiences around five hours of congested conditions each day. By 2025, congestion in the major corridors is expected to grow, particularly along arterial corridors such as SR 291, SR 2 and SR 290 that radiate from the urban core area. Segments on I-90 west of downtown will see congestion increasing from less than two hours currently to around five hours by 2025.

Longer Travel Times

Travel times for typical commuter routes between major destinations in the Central Puget Sound region currently average around 40 minutes during the PM peak period. By 2025, according to the computer model, these same commutes are expected to increase on average to around 60 minutes. In the Vancouver area, travel times between major trip origins and destinations are also expected to increase by 50% over the next 20 years from 16 to 24 minutes according to the computer model. In Spokane, travel times between major origins and destinations are expected to increase from 16 to 18 minutes, or by about 14%.[10]

Reduced Efficiency

Congestion causes lost efficiency, or productivity, on the roadway system. For example, the maximum throughput[11] of vehicles on a freeway, about 2,000 vehicles per lane per hour, occurs at speeds of 45-50 mph. As demand increases, congestion causes a drop in speeds and the throughput (efficiency) of the highway is reduced dramatically. When congestion causes drivers to lower their speeds to 30 mph, the throughput on a freeway drops below 1,700 vehicles per lane per hour, and may fall to as low as 700. Depending on conditions, only about half the existing capacity will be effectively used at a time when it is needed the most. This point is illustrated in Figure 11, which depicts the percentage of freeway productivity that is currently lost on Puget Sound freeways when congestion is at its worst.

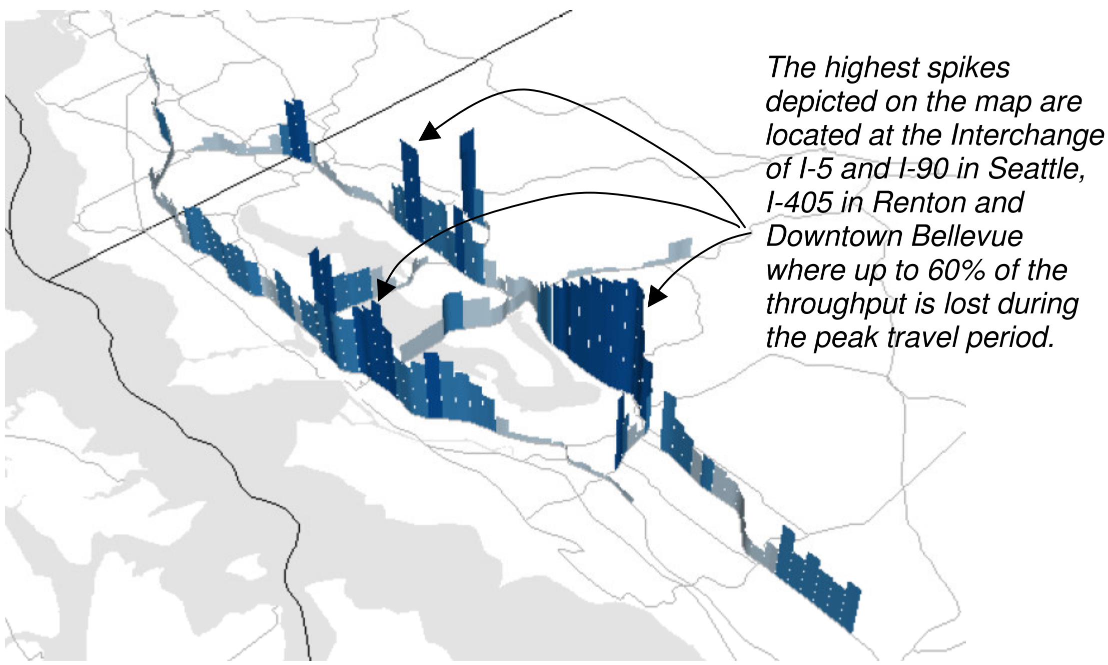
[9] The study area extends across the Columbia River to I-84 in Oregon

[10] The North Spokane Corridor project is assumed in the 2025 Baseline, significantly improving travel times for north-south trips.

[11] Throughput is defined as the number of vehicles that can pass through a roadway segment during a given time period, typically measured for one hour.

By 2025, congestion on freeways in the Central Puget Sound region is projected to last for more than ten hours each day on some freeways, a scenario in which the morning and afternoon peak periods would merge together. The throughput loss during these congested hours would be more dramatic than the loss experienced today.

Figure 11: Throughput Loss on Puget Sound Freeways When Congestion is at its Worst



Confronting this Challenge – What Scenarios were considered?

There are several approaches to addressing roadway congestion: improving roadway operation to make capacity more available; expanding highways and transit systems; augmenting system investments to reshape transportation demand; and changing policy to value price roadways.

One approach that almost everyone agrees on is to improve the operations of roadways so that their inherent capacity is more effectively available. This includes a range of strategies from traffic light synchronization and ramp meters, to improved traveler information systems and faster clearance of disabled vehicles and crash scenes on the highways. These strategies are familiar in Washington State where many such approaches have been pioneered. More needs to be done and is being done. Estimates vary as to the proportion of highway congestion that is due to events and situations on the roadways that are unrelated or little related to the basic demand/capacity imbalance. Almost everyone agrees that demand/capacity imbalance is very large. This study, however, does not specifically model and address the transportation congestion improvements that can be gained from more emphasis in these areas.

Another approach is to increase major new capital investment in expansion of highways and transit systems (and, for transit, perhaps an increase in operating investment as well). This study examines several hypothetical forms those investments could take.

Another approach is to augment the kind of system investments just described with investments that would reshape the nature of transportation demand. For example, allowing flexible work hours will enable commuters to avoid congested peak periods and expanding vanpool programs will enable more people to share rides and reduce single occupancy vehicle travel.

Another approach is to change current policy by which demand on the use of roadways is unconstrained and unmanaged by almost any form of demand-variable pricing ("value pricing") for roadway use. Value pricing of roadways, a very conventional approach in a market-based economy, would assure that the capacity of roadway investments were better utilized by preventing the lost roadway productivity that accompanies the low vehicle throughputs that characterize congestion. This would also assure that very high value roadway uses (including reliable and speedy transit whether in buses or vanpools) would be available.

This study looked at scenarios drawing on some of these approaches. The scenarios included two "bookend" strategies focused on mode-intensive capital investment: "Highway Focus" and "Transit Focus."

Highway Focus employed new highway capacity (adding new lanes) as the only measure to address congestion. It envisioned that new lanes would be added to those roadways that would be congested as predicted by the computer model.

Transit Focus employed transit (buses, light rail, etc) as the only means to address congestion. It envisioned that every traveler would have convenient access to high speed transit to everywhere within the regions.

Three blended strategies staked out intermediate points between the two bookend strategies: "Highway and Transit Intensive," "Highway Emphasis" and "Transit Emphasis."

Blended strategy: **Highway and Transit Intensive** blended the most productive highway and transit expansions found in the two bookend scenarios. Its purpose was to test the extent to which congestion could be relieved by investing aggressively in both highways and transit improvements.

Blended strategy: **Highway Emphasis** included a high investment in the roadway network, but a relatively lower investment in transit improvements.

What did we learn from the analysis?

- *Rapid population and employment growth will dramatically increase travel demands in our state's urban areas by 2025*. Without substantial increases in transportation capacity or significant changes to travel behavior, traffic congestion will get much worse than today – total delay will increase threefold if people continue to travel like they do today.
- *Roadway improvements can effectively reduce delay*. For scenarios that involve highway improvements, travel times for many commute trips would be reduced in 2025 with the increased capacity as compared to the 2025 baseline. However, these improvements would only keep the congestion from getting worse than today.
- *Major roadway expansion is very expensive within urban areas due to geographic and man-made constraints*.
- *The models did not show transit to be effective in reducing congestion*. However, transit investments can be effective in moving people during peak periods in urban corridors, where they may provide travelers with an alternative way to deal with congestion.
- *Among the efficiency techniques that address congestion from the demand side, roadway pricing appears to be the single most effective strategy in reducing traffic congestion*. Pricing can be combined with other transportation management strategies to further system efficiency gains.

Blended strategy: **Transit Emphasis** included a high investment in transit improvements, but a relatively lower investment in roadway improvements (about one third of the new capacity included in the Highway Focus Scenario).

Another blended strategy, **Transit Emphasis with Pricing**, included the same level of highway and transit improvements tested in the Transit Emphasis Scenario, with the addition of tolling all the heavily traveled corridors (freeways and expressways).

Finally, in order to create a common benchmark against which all strategies could be compared, **2025 Baseline Scenario** was created and modeled. This scenario included all the existing facilities plus funding secured projects (such as the Nickel projects and Light Rail to University of Washington). More detail on each of the scenario strategies follows:

Highway Focus, The Highway Focus Scenario tested an aggressive highway expansion program in each region. In the Central Puget Sound region, the Highway Focus Scenario's road investments would provide 1,230 more freeway and 730 more arterial lane miles than the 2025 Baseline Scenario. This represents a 16% increase in total lane miles (Table 2). Similar highway strategies were tested in Vancouver and Spokane.

Table 2: Lane Miles to be Added in the Highway Focus Scenarios*

Facility Type	Central Puget Sound			Vancouver**			Spokane		
	Miles Added	% Increase	% Change in Population	Miles Added	% Increase	% Change in Population	Miles Added	% Increase	% Change in Population
Freeways	1,230	52%	32%	100	45%	42%	137	60%	47%
Arterials	730	7%		186	25%		382	25%	
Total	1,960	16%		286	29%		518	30%	

* Lane miles compared with 2025 Baseline Scenario
** Data for Clark County only. Other lane miles added in Portland, Oregon.

Transit Focus:

A Transit Focus Scenario was developed in each region to test an aggressive expansion in transit infrastructure and service (Table 3). Transit service hours would increase by more than 100% in both the Central Puget Sound and Vancouver regions compared with the 2025 Baseline; the expansion of transit service hours was a more modest 38% in Spokane. The Central Puget Sound region High Capacity Transit (HCT) network expanded by 400%, while new HCT facilities were introduced in both Vancouver and Spokane.

Table 3: Transit Service and Facilities to be Added in Transit Focus Scenarios*

Service Addition	Central Puget Sound		Vancouver		Spokane	
	Units	% Increase	Units	% Increase	Units	% Increase
Transit Service Hours***	26,000 hours	104%	1,336 hours	149%	1,750 hours	38%
Miles of High Capacity Transit (HCT)	176 miles	490%	21 miles	No previous HCT	31 miles	No previous HCT

* Compared to the 2025 Baseline
** Data for Clark County only; other transit service added in Portland, Oregon
*** Average weekday bus equivalent revenue hours

Value Pricing:

The study evaluated three distinct pricing strategies:

- Regional Value Pricing – Applied variable tolls based on congestion levels to all freeways and arterials in the region without any highway or transit capacity investments.
- Roadway Pricing – Applied variable tolls to most freeways combined with moderate freeway expansion and extensive transit improvements.
- High Occupancy Toll (HOT) Lanes – Created a two-lane HOT system in major freeway corridors where freeway lanes were added.

Regional Value Pricing

The regional value pricing scenario assumed that all freeways, highways and most arterials in the Central Puget Sound and Vancouver regions would be tolled. The toll would be zero when traffic demand is low and roads are uncongested, with the toll rising as demand builds to match demand to available roadway capacity. At high demand times, increasingly higher tolls encourage some people to alter their travel behavior, either by diverting their trips to an alternate route, by changing to a different travel mode (transit or carpool), or by changing their trip to a less congested time.

Caution should be taken in relying on these results because of challenges in using the regional travel demand models to simulate pricing on all roads.

Additionally, the cost and political acceptability of implementing widespread pricing for roadway use are uncertain and warrant further study.

Table 4 shows which pricing strategies were analyzed in each region.

Table 4: Value Pricing Strategies Evaluated in Congestion Relief Analysis

Strategy	Central Puget Sound	Vancouver	Spokane
Regional Congestion Pricing	X	X	
Freeway Pricing	X	X	
High Occupancy Toll (HOT) Lanes*	X	Not Evaluated	

*HOT Lanes were examined using a more simplified sensitivity test methodology

What Were the Results?

The Congestion Relief Analysis provides perspectives on how well these different solution sets would address the congestion problems in the State's major urban areas. The study examined results at both a region-wide and a corridor level. The results are summarized below.

Can We Solve Congestion with Significant Highway Expansion?

The modeling showed that large-scale roadway expansion could effectively reduce highway delay. However, unusual or unexpected future population and job growth could limit the ability of these improvements to reduce total regional

Where Highway Investments Are and Are Not Effective

In the urban core of our regions, expanding highways is very expensive due to natural and man-made constraints. For example: to serve the growing demand on I-5 through downtown Seattle, adding six lanes for ten miles was tested in the Highway Focus Scenario. A tunnel was assumed for this segment due to the right-of-way limitations and very high property costs. The cost of this tunnel could be $150-200 million per lane mile, for a total cost in excess of $10 billion (2004 $) and considerably more if built in the future. If the tunnel were built, it is estimated that the daily hours of congestion on I-5 could be reduced from ten to seven hours in 2025 (today it is eight hours).

In areas where right-of-way is relatively inexpensive, highway investments can be expected to provide longer term benefits. For example: one lane added in each direction for 25 miles on SR 18 from Auburn to I-90 would cost in the vicinity of $1.5 billion. It could reduce the daily hours of congestion from seven to two hours in 2025 (today it is two hours).

delay to below today's levels. Figure 12 illustrates how delay was reduced in Spokane with the Highway Focus Scenario.

Large-scale highway expansion was found to be very expensive (see Table 5). In heavily traveled corridors, relatively less expensive right-of-way has been used and opportunities are limited for future highway expansion due to man-made and/or natural environmental constraints.

Figure 12: Daily Hours of Delay in the Highway Focus Scenario for Spokane

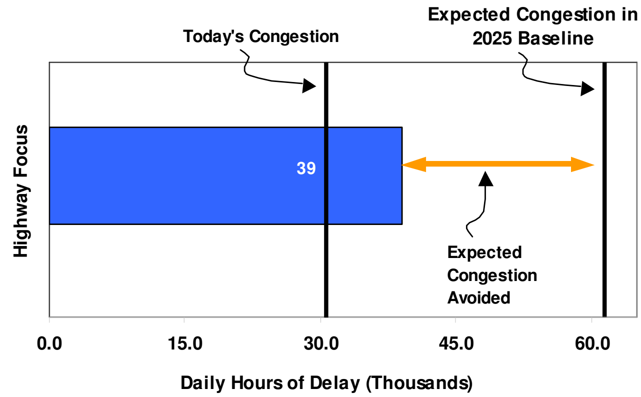


Table 5: Costs to Implement the Highway Focus Scenarios

Regions	Capital Cost* Range ($ Million)		Annual Operations and Maintenance Costs* ($ Million)
	Low End	High End	
Central Puget Sound	$ 79,100	$ 104,000	$ 150
Vancouver**	$ 3,100	$ 4,100	$ 10
Spokane	$ 6,800	$ 8,900	$ 25

* Costs in Year 2003 Dollars
**Implementation costs do not include Portland area improvements

While major system-level expansion of the highway system is effective in reducing delay, the predicted benefits may not be enough to offset the cost of building such a highway system[12].

Table 6: Benefits and Costs for the Highway Focus Scenarios

Regions	2025 Annual Benefits Range ($ Million)		Annualized Capital and 2025 O&M Costs Range ($ Million)	
	Low End	High End	Low End	High End
Central Puget Sound	$ 1,500	$2,200	$ 2,500	$ 3,700
Vancouver*	$ 54	$ 80	$ 77	$ 100

Notes: Benefits and costs are expressed in constant 2003 dollars including present value discounting;
Benefits and costs were evaluated for Vancouver only and do not include benefits and costs accrued/expended for the Portland area;
Spokane data not available

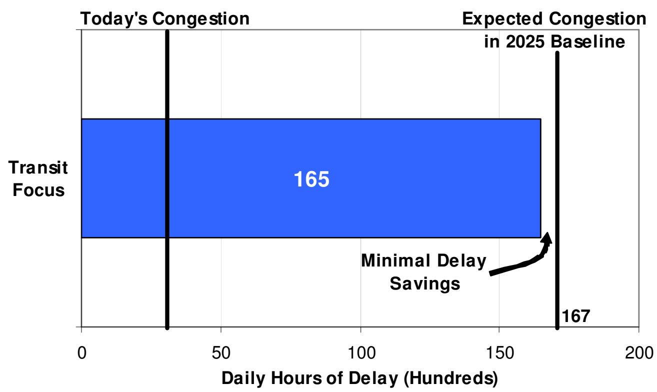
Can We Solve Congestion with Significant Transit Improvements?

Major transit expansion in the three urban areas would provide an alternative to congested roadways for people traveling to/from urban centers during peak periods. However, transit alone was not effective in reducing roadway delay. The lack of supportive land use densities

[12] The two primary reasons that the Highway Focus Scenario did not prove to be cost-beneficial are 1) improvements in densely developed areas (i.e., I-5 tunnel through downtown Seattle) are extremely expensive and 2) peripheral improvements generate increasingly fewer user benefits even though they are still very costly to construct. Certain components of this and other scenarios, especially strategically located/corridor-specific improvements, may prove to be cost-beneficial on their own.

throughout the region limits transit's ability to capture many trips that are made by auto. Figure 13 shows the daily hours of delay in the Transit Focus Scenario for Vancouver.

Figure 13: Daily Hours of Delay in the Transit Focus Scenario for Vancouver



Where Transit Investments Are and Are Not Effective

Transit is not an effective congestion relief tool by itself. However, transit can help move high volumes of people within and between urban centers. In these settings, transit investments provide travelers with an alternative to congested highway corridors.

For example - across Seattle's Ship Canal: Congestion remains nearly the same for each of the scenarios tested, but the transit scenarios move close to 25% of total person trips.

In many of the corridors where extensive transit expansion was tested, the computer model showed that ridership would increase substantially but still remain a relatively small share of the overall trips. As a result, roadway congestion remained almost unchanged. Based on national experience, transit investments seem to be most effective when targeted to corridors with sufficient population densities and large employment centers.

For the Central Puget Sound and Vancouver regions, the capital investment costs for implementing the Transit Focus Scenario are considerably lower than for the Highway Focus Scenario. However, the annual operations and maintenance costs for transit are much higher (Table 7). In the Central Puget Sound region, the Transit Focus Scenario would cost almost $900 million annually to operate and maintain.

Table 7: Costs to Implement the Transit Focus Scenarios

Regions	Capital Cost* Range ($ Million)		Annual Operations and Maintenance Costs* ($ Million)
	Low End	High End	
Central Puget Sound	$24,900	$ 32,800	$ 890
Vancouver	$ 1,800	$ 2,400	$ 80
Spokane	$ 1,300	$ 1,700	$ 56

* Estimated Costs in Year 2003 Dollars

A transit-oriented solution produces benefits for transit riders, but not much congestion relief benefit for those traveling by auto. Overall, the predicted benefits may not be enough to offset the high construction costs and annual operations and maintenance costs (Table 8).

Table 8: Benefits and Costs for the Transit Focus Scenarios

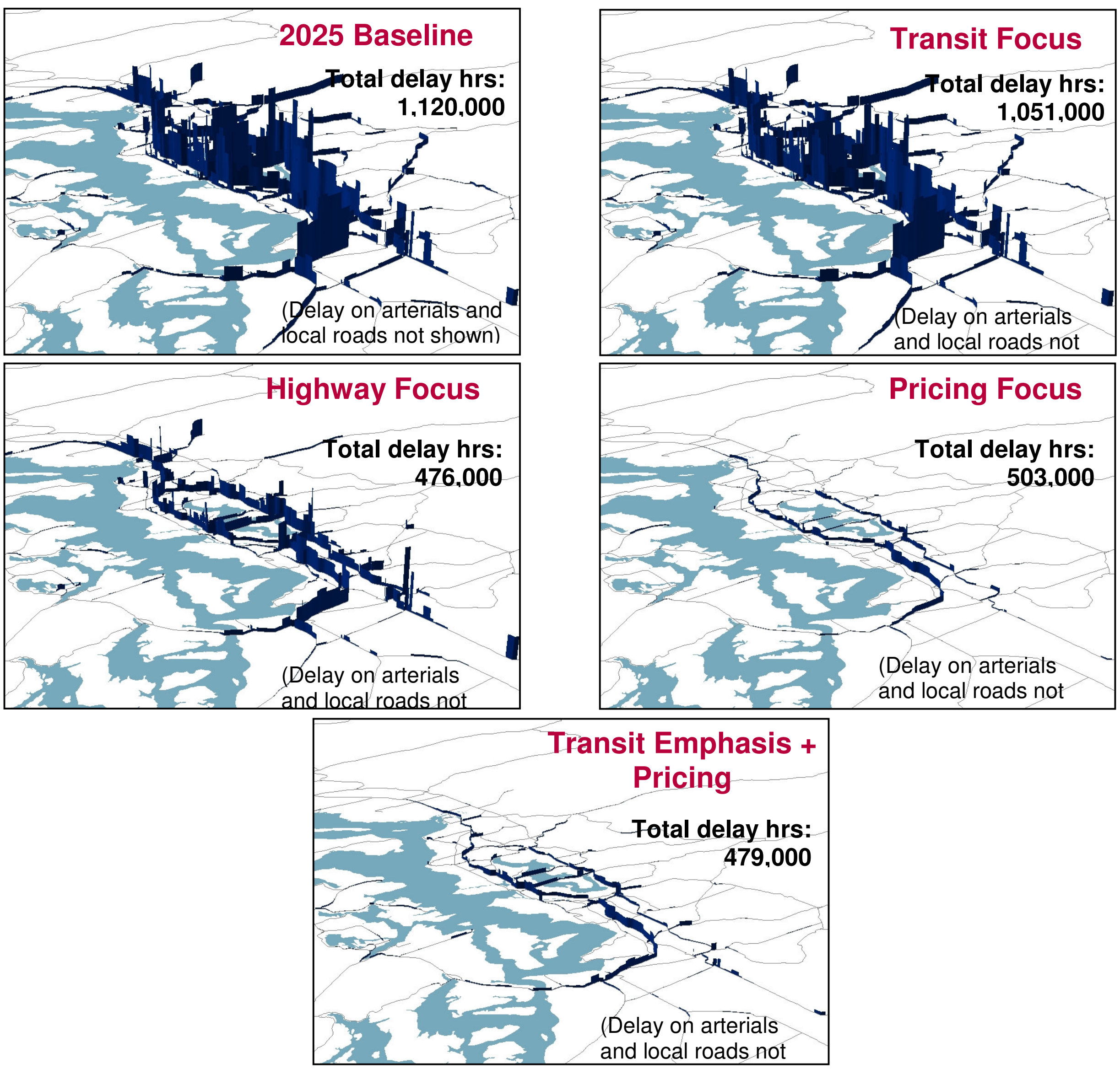
Regions	2025 Annual Benefits Range ($ Million)		Annualized Capital and O&M Costs Range ($ Million)	
	Low End	High End	Low End	High End
Central Puget Sound	$ 480	$ 730	$ 1,200	$ 1,500
Vancouver	$ 34	$ 52	$ 91	$ 108

Note: Benefits and costs are expressed in constant 2003 dollars inclusive of present value discounting; Spokane data not available.

Does Charging Roadway Tolls Reduce Congestion?

Each of the pricing strategies improved the efficiency of the transportation system as compared to the same conditions without pricing. Figure 14 illustrates this point.

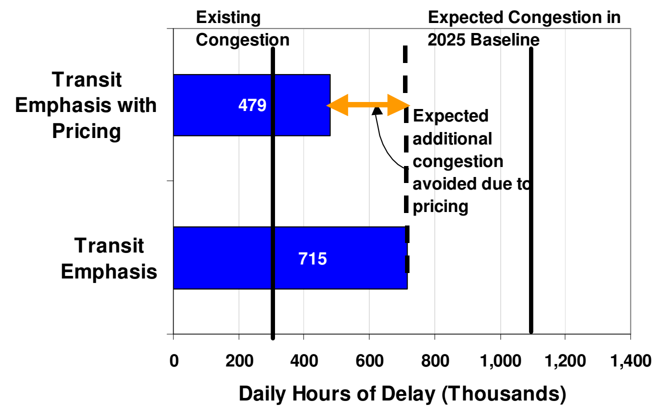
Figure 14: Delay per Mile per Day on Major State Highways in the Central Puget Sound Region



Regional congestion pricing, evaluated in the Pricing Focus Scenario, was the most effective of all tested scenarios in terms of vehicle delay saved for dollar spent. While the delay savings were comparable to a heavy emphasis on highway expansion, the implementation and environmental costs of this demand-side approach were much lower. The toll revenues generated by a regional value pricing program could also be put to beneficial use on behalf of all travelers[13].

Adding freeway value pricing to the capacity investments of the Transit Emphasis Scenario (Figure 15) increases highway efficiency and improves the effectiveness of the same scenario without pricing.

Figure 15 Effectiveness of Freeway Value Pricing in Central Puget Sound Region

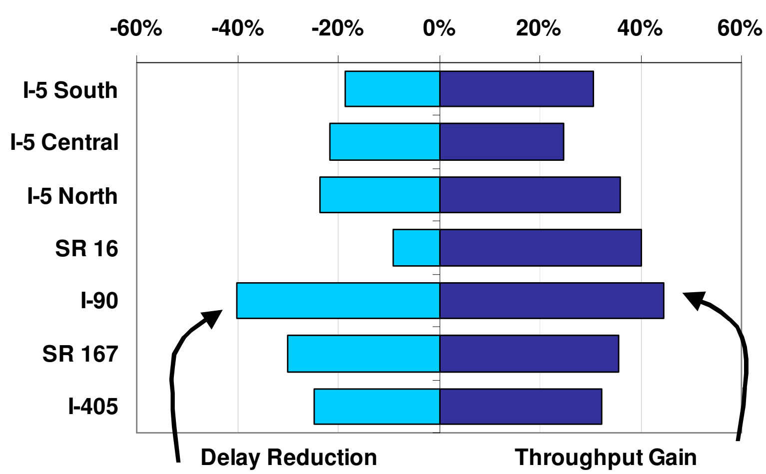


HOT Lane Network

This study also evaluated the effects of creating a High Occupancy Toll (HOT) lane system in the Central Puget Sound region. HOT lanes use both tolling and occupancy restrictions to manage the number of vehicles traveling on them, maximizing the volume of vehicles in the lanes while maintaining travel speed at or near the posted speed limit. HOT lanes provide non-HOV travelers with a choice of paying a toll to use relatively uncongested travel lanes.

A HOT lane network for this analysis was defined as two lanes in each direction on a freeway comprised of an existing HOV lane and the adjacent general purpose lane (except SR 16 where only one lane each direction was assumed). The results showed that targeted pricing with HOT lanes not only reduces delay, but also makes the entire freeway system more efficient. Figure 16 shows the results in the Central Puget Sound region for the HOT lane system.

Figure 16 Potential Peak Period Percent Delay Reduction and Efficiency Gains with HOT Lanes in the Central Puget Sound Region



[13] This study did not make any assumptions regarding the potential uses of net toll revenues.

What if We Combined Investment Options?

Investing in a mix of roadway and transit produced similar levels of congestion reduction when compared to the Highway Focus Scenario (Figure 17). The mixed-mode solutions tend to be most effective in and around the urban cores where investment costs are high and congestion is persistent for much of the day.

Figure 17: Delay Savings for Mixed-Mode Scenarios are Similar to the Highway Focus Scenario

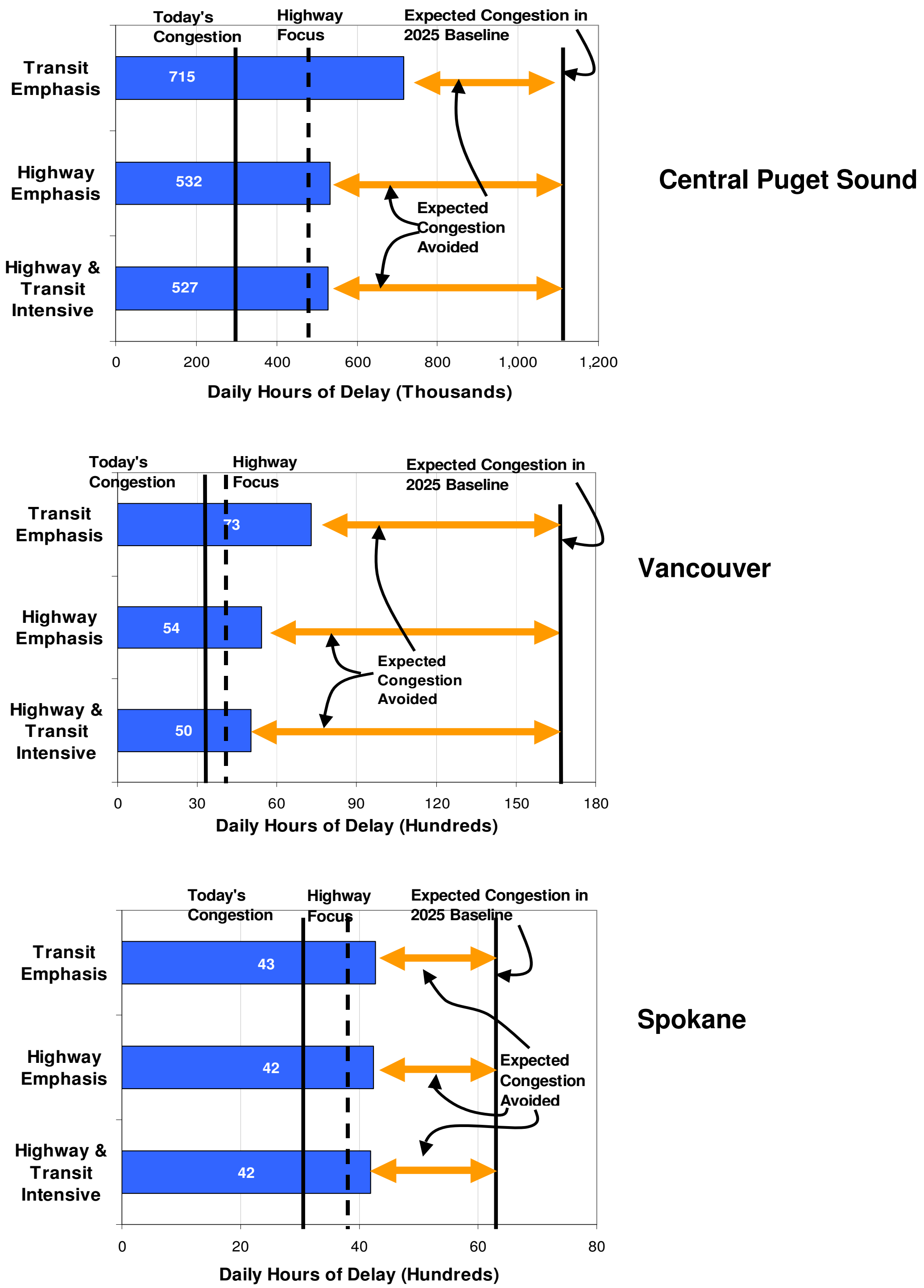
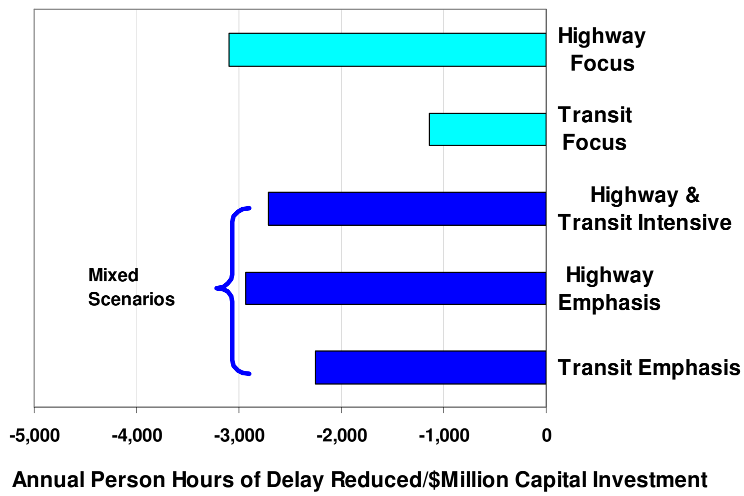


Figure 18 shows the cost effectiveness of the scenarios that focus on capital improvements. While the Transit Focus Scenario didn't do much to reduce congestion, the mixed transit and highway improvement scenarios were almost as effective as the Highway Focus Scenario. Because transit can serve a large number of trips in heavily traveled corridors; it presents an attractive alternative for travelers otherwise caught in traffic. Since buses often travel on the same roadways as other vehicles, a well thought out combination of transit and highway improvements can be complementary to each other.

Figure 18: Cost-Effectiveness of the Mixed-Mode Scenarios in Central Puget Sound

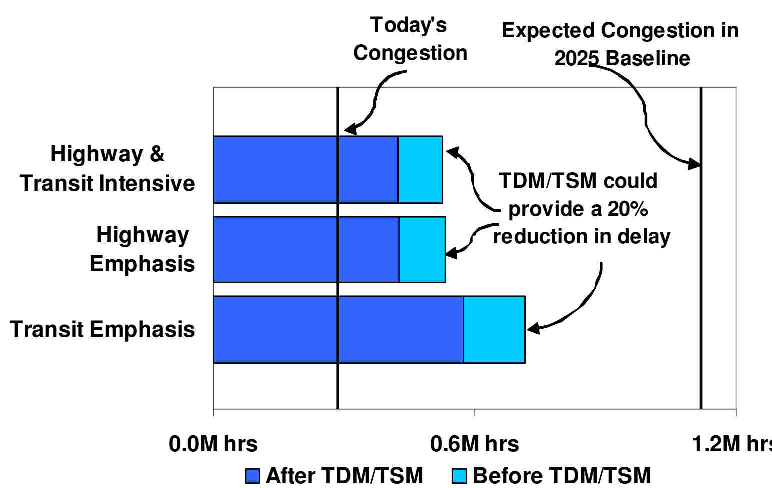


How Much Can Demand Management or System Efficiency Measures Reduce Congestion?

Emphasizing efficiency is important to ensure maximum productivity of the highway system. The Congestion Relief Analysis examined the effects of the following efficiency measures:

- Transportation Demand Management (TDM) – Strategies to reduce vehicular demand during peak travel time.
- Transportation Systems Management (TSM) – Strategies to improve the operating efficiency of highway and transit systems

Figure 19: 4% Trip Reduction Plus TSM's Potential Effects on Daily Vehicle Hours of Delay in Puget Sound



Modeling analysis indicated that, if TDM can reduce 4% of overall vehicle trips, combined with TSM improvements, total system delay could be reduced by as much as 20% (Figure 19). However, to achieve an additional 4% trip reduction over the already implemented programs would require a strong determination to implement an aggressive package of TDM and TSM strategies region wide.

How Can We Apply these Findings?
While the analyses are not intended to replicate or supplant ongoing planning processes, the broad range of the scenarios offers a perspective on how different modes work on their own and in combination. The congestion relief findings can be applied to help regional and corridor planning. The results may help in setting the range of regional transportation strategies to consider and screening the most effective modal options. At the corridor level, the metrics provide useful background data and insights into the effectiveness of transportation strategies. While not a substitute for detailed corridor planning and design, these results can help put corridor strategies into perspective with similar strategies elsewhere in the region.

What Can Be Done to Improve the Analysis?
While the methodology and assumptions used in this analysis apply the best available modeling tools, they have limitations. Topics that could be improved upon in future studies include the following:

<u>The full range of effects of pricing on travel behavior.</u> Pricing strategies were analyzed to the extent that they could be modeled within a region's travel forecasting process. These models do not fully capture the spectrum of potential pricing effects. Better analysis tools are needed to evaluate the impacts of pricing on roadway and transit use.

<u>Effects of congestion strategies within specific highway and transit corridors.</u> Most detailed evaluations of corridor strategies are best handled as part of focused corridor studies.

<u>Effects on land use allocation and mix.</u> Major transportation investments impact land use patterns. Further study is needed to determine how the regions' land use patterns could be affected by various transportation investment scenarios.

<u>Refinement of benefit-cost methodology.</u> The benefit-cost methodology should be refined to match refinements in the regional travel demand models to better address the effects of pricing and mode shift behavior. The methodology could also be expanded to a multi-year evaluation period by providing additional travel demand modeling for a second forecast horizon year beyond 2025.

<u>Corridor effects of Transportation Demand Management strategies.</u> Further testing of corridor-based TDM strategies would produce more accurate results than the system-wide factors applied in this study.

<u>Detailed origin and destination traveler profiles.</u> Additional analysis of travel patterns for personal travel and freight would assist in understanding the dynamics of the analysis result